

PROJECT DATA																			
Joram Hopenfeld - 00GO10613																			
Distributed Optical Fiber Sensors For Continuous Liquid Level Tank Gauging																			
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Subcontractor(s):		B & R Number(s):	ED1906020																
		PES Number(s):	00-2424																
EERE Program:	FreedomCAR & Vehicle Technologies	State Congressional District:	MD - 8																
<p><b>PROJECT SCOPE:</b> The overall objective of this project is to validate, through prototype fabrication and field testing, that the Noverflo Multipoint Tank Gauge can be manufactured for \$3- \$4 per sensor, and perform as projected. The work scope includes design of special tools for fabrication, fabrication of prototypes, design of complimentary equipment, installation, testing and reporting. Estimates from the year 2000 show that the railroad industry lost 20 million barrels of fuel to spillage, or a loss of \$178 million dollars. With the NMTG installed, dramatic energy and environmental savings will be derived for the railroad and other industries.</p>																			
<p><b>FINANCIAL ASSISTANCE</b></p> <table> <tbody> <tr> <td>Approved DOE Budget</td> <td>\$174,284</td> <td>Approved DOE Share</td> <td>\$174,284</td> </tr> <tr> <td>Obligated DOE Funds</td> <td>\$174,284</td> <td>Cost Share</td> <td>\$105,000</td> </tr> <tr> <td>Remaining Obligation</td> <td>\$0</td> <td></td> <td></td> </tr> <tr> <td>Unpaid Balance</td> <td>\$0</td> <td><b>TOTAL PROJECT</b></td> <td><b>\$279,284</b></td> </tr> </tbody> </table>				Approved DOE Budget	\$174,284	Approved DOE Share	\$174,284	Obligated DOE Funds	\$174,284	Cost Share	\$105,000	Remaining Obligation	\$0			Unpaid Balance	\$0	<b>TOTAL PROJECT</b>	<b>\$279,284</b>
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Project Period: 9/15/00-8/31/03																			

# **TECHNICAL PERFORMANCE**

**DE-FG36-00GO10613**

**Joram Hopenfeld**

**Distributed Optical Fiber Sensors For Continuous Liquid Level Tank Gauging**

## **PROJECT SYNOPSIS**

The overall objective of this project is to validate, through prototype fabrication and field testing, that the Noverflo Multipoint Tank Gauge (NMTG) can be manufactured for \$3- \$4 per sensor, and perform as projected from five years of previous bench and field testing. If these objectives are achieved, detailed plans will be drawn for offering low price/high quantity NMTG versions for OEM applications. Four prototypes of the new NMTG level instruments will be fabricated and field-tested to prove their performance and relatively low cost to manufacture. The proposed work scope for the budget period includes design of special tools for fabrication, fabrication of the prototypes, design of complimentary equipment (including data transfer to control system computers), installation, testing and reporting. Energy and environmental savings can be realized by a number of industries using the NMTG year 2000 estimates that the railroad industry lost 20 million barrels of fuel to spillage, or lost \$178 million dollars. Energy and environmental savings will be derived from the ability of the NMTG to help eliminate such losses.

## **SUMMARY OF TECHNICAL PROGRESS**

This is a FY00 award and work commenced on 06/01/00.

2001 activities are summarized. Performance requirements for the Noverflo Multipoint tank Gauge (NMTG) have been established. Two designs have been selected, one utilizing a PC camera, the other based upon a phototransistor array. The design using the PC camera shows the most promise. Prototypes have been manufactured for testing and evaluation.

2002 activities are summarized. The NMTG prototype was delivered to Norfolk Southern Railroads for field-testing. Another prototype is being completed for gasoline applications that will be installed at an industrial site. A four-month land test in diesel fuel was successfully completed. Dr. Hopenfeld initiated a market study to identify where the NMTG needs modifications to be more responsive to market needs.

2003 activities are summarized. The NMTG was field tested by Norfolk Southern Railroad. Other NMTG prototypes are being designed for land applications. Joram Hopenfeld is working with OMNTEC, Manufacturing (commercialization partner) to understand and develop market strategy.

## **SUMMARY OF PLANNED WORK**

The Final Report, due 06/29/04, has not been submitted.

## **PROJECT ANALYSIS**

A no-cost extension was approved for a new end date of 03/31/04. After review of the Final Report, an analysis will be provided to understand the project accomplishments.

**ACTION REQUIRED BY DOE HEADQUARTERS**

No action is required from HQ at this time.

# **STATEMENT OF WORK**

**DE-FG36-00GO10613**

**Joram Hopenfeld**

## **Distributed Optical Fiber Sensors For Continuous Liquid Level Tank Gauging**

### **Detailed Task List**

#### **Task 1. Develop NMTG Specifications for Both Prototype Applications**

Based on discussions with Earthsafe and Norfolk Southern, specifications will be developed for three prototypes for each application.

#### **Task 2. Design Detector Enclosure and Develop Digital Camera and LED Connector**

A suitable commercial LED/detector is a Hewlett Packard product, which sells for \$15. In-house design and fabrication of a similar pair will reduce the above cost to about \$0.72. This task will also develop the housing for the LEDs and the detectors. The 4 mm diameter, 20 mm long housing will be molded from black nylon.

#### **Task 3. Design, Fabricate and Test Circuit Boards**

To increase reliability and reduce power consumption, the power supply to each sensor will be pulsed and sequenced with RH 4017 so that each sensor will operate for several seconds at selected time intervals. At any given time, one fraction of the sensors is wet while the other fraction is dry, producing five and zero volt signals, respectively. After transmitting these signals to microprocessors, the liquid content in the tank is calculated by multiplying by geometry constants and the tilt angle. This output is provided directly or through a Dynamic Tag to a host computer. Mrs. R. Hopenfeld will design and test the electronics. The circuit boards will be fabricated by Jobe & Co, Inc.

#### **Task 4. Design and Manufacture Special Purpose Tool Prototypes**

This task will focus on designing and fabricating necessary tools for mass production with the cooperation of ACT MicroDevices, Inc. and Midland Manufacturing Inc. These will include: 1) a tool for gaping the sensors before dispensing the epoxy, 2) a tool for rotating the circuit board and indexing each sensor, and 3) connectors to attach a bundle of 9 micron fibers to 1 mm glass fiber. This task also includes testing various epoxy coatings for ease of application and compatibility with plastic sensors.

#### **Task 5. Prepare Dynamic Tag and Computer Interfaces**

This task will develop a fuel tank monitor (FTM) function that interfaces with both a locomotive dynamic tag and host computer. The design will be based on the AAR requirements specified in the AAR standard (8), LSI Communications Specification (X), the draft Locomotive Fueling Interface Standard and Amtech User Guide for AT 5704 Tag. This will be implemented via a PLC system using circuit cards for interfaces to the locomotive computer for generating/accepting HDLC protocol with RS-422, and the dynamic tag for generating EPROM input.

#### **Task 6. Assemble and Test Six Prototype NMTG (Three for Each Application)**

The prototypes will be assembled and tested prior to installation at the two sites.

#### **Task 7. Install and Test Six NMTG Prototypes**

The six prototype units will be installed and tested at Earthsafe and Norfolk Southern (three at each site). The tests will confirm the performance of the prototypes as projected from five years of previous bench and field testing.

#### **Task 8. Conduct Market Studies**

Marketing studies, with help from Midland Manufacturing, Inc., will be conducted. The purpose of the studies is to identify potential markets in chemical and chip manufacturing industries. Also, markets in the pharmaceutical industry will be identified with the assistance of New Horizons Diagnostic Company.

#### **Task 9. Project Management and Reporting**

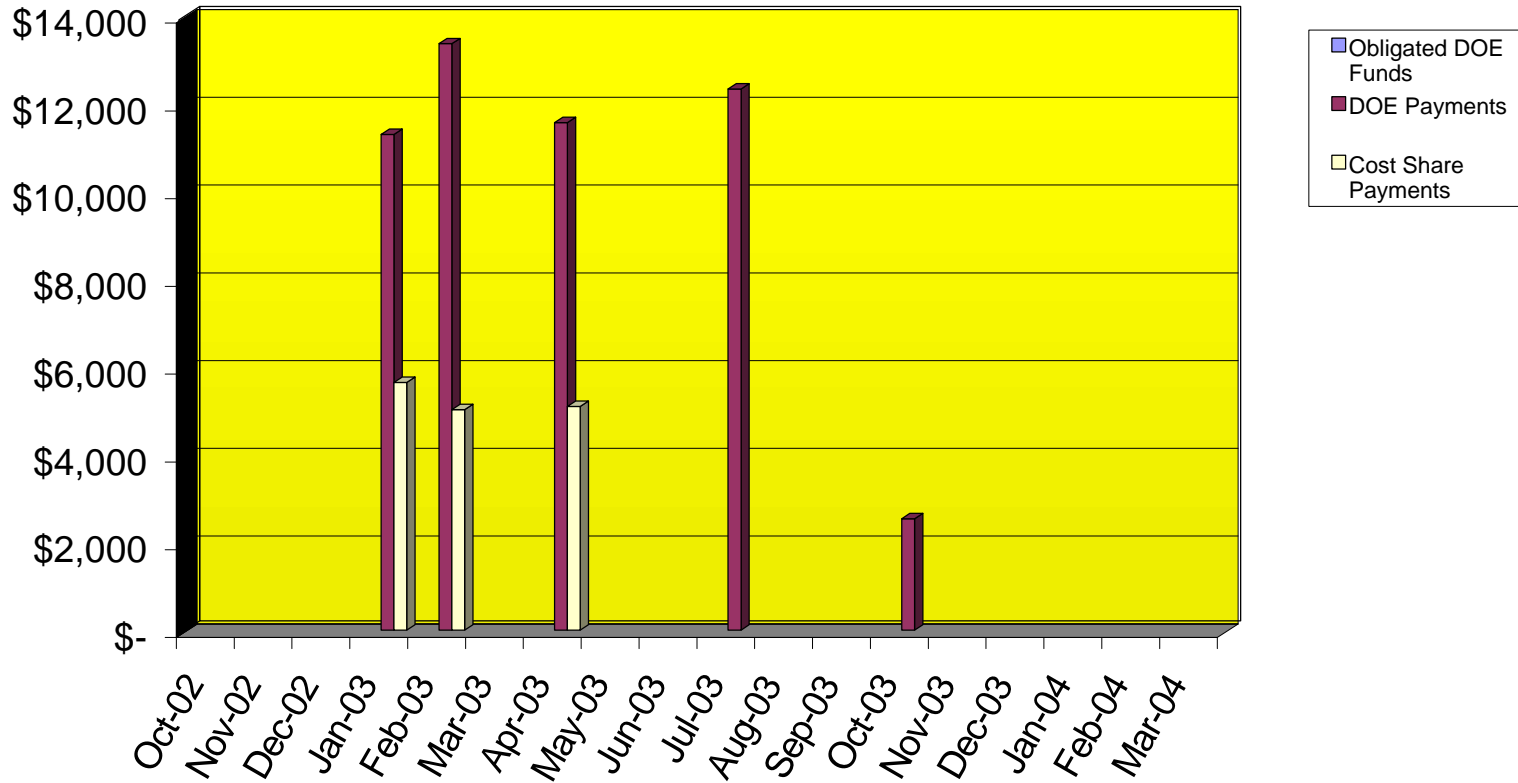
These tasks are to provide the required DOE reports using the standard I&I Program formats.

## Project Cost Performance in DOE Dollars for Fiscal Year 2003

DE-FG36-00GO10613

Dr. Joram Hopenfeld

Distributed Optical Fiber Sensors for Continuous Liquid Level Tank Gauging



	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03
Obligated DOE Funds	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
DOE Payment	\$0	\$0	\$0	\$11,300	\$13,367	\$0	\$11,570	\$0	\$0	\$12,336	\$0	\$0
Cost Share Payment	\$0	\$0	\$0	\$5,650	\$5,025	\$0	\$5,100	\$0	\$0	\$0	\$0	\$0

	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	PFY*	Cumulative
Obligated DOE Funds	\$0	\$0	\$0	\$0	\$0	\$0	\$174,284	\$174,284
DOE Payment	\$2,539	\$0	\$0	\$0	\$0	\$0	\$123,172	\$174,284
Cost Share Payment	\$0	\$0	\$0	\$0	\$0	\$0	\$82,341	\$98,116

Approved DOE Budget:	\$174,284
Approved Cost Share Budget:	\$105,000
Total Project Budget:	\$279,284

\* Prior Fiscal Years

## Joram Hopenfeld - 00GO10613

Task Name	Start	Finish	2001				2002				2003							
			Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4					
Develop NMTG Specifications for Both Prototype Applications	Thu 6/1/00	Fri 2/1/02	<div></div> 100%															
Design Detector Enclosure and Develop Digital Camera and LED Connector	Fri 9/1/00	Wed 5/1/02	<div></div> 100%															
Design, Fabricate and Test Circuit Boards	Wed 11/1/00	Thu 8/1/02	<div></div> 100%															
Design and Manufacture Special Purpose Tool Prototypes	Thu 2/1/01	Fri 5/30/03	<div></div> 100%															
Prepare Dynamic Tag and Computer Interfaces	Fri 6/1/01	Thu 2/14/02	<div></div> 100%															
Assemble and Test Six Prototype NMTG (Three for Each Application).	Mon 4/1/02	Thu 5/15/03	<div></div> 100%															
Install and Test Six NMTG Prototypes	Mon 12/3/01	Thu 5/15/03	<div></div> 100%															
Conduct Market Studies	Mon 6/3/02	Fri 2/14/03	<div></div> 100%															
Prepare and Submit Final Report	Mon 9/2/02	Tue 9/30/03	<div></div> 0%															